DOCUMENT RESUME

ED 461 522 SE 065 685

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TITLE Physics Problem Solving Research Using Protocols.
PUB DATE 2002-00-00
NOTE 7p.
PUB TYPE Opinion Papers (120)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Educational Research; Higher Education; *Physics; *Problem Solving; *Protocol Analysis; Science Education; Secondary Education

ABSTRACT

This paper presents an overview of research on physics problem solving using verbal protocols. It asserts that the understanding of physics problem solving strategies enables researchers to write computer programs, which can automatically solve physics problems without the users having to be experts in physics. This, in turn, can generate more effective teaching methods for physics courses because such programs can be the basis for computer-assisted instruction, or CAI. This type of instruction combined with the program could answer questions about solving various physics problems and could also have the ability to analyze where the student went wrong in his or her solution(s). It is for reasons such as these that it is important to enhance the amount of research going into physics problem solving strategies. (Contains 12 references.) (YDS)

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ED 461 522

physics problem solving research using protocols

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Research in problem solving strategies in science education represents current practice. This is a shift from the direction of science education research in the 1960's and 1970's which emphasizes the structure of knowledge and the central curricula. In the 1980's the direction of science education shifted from the "what" to the "why" (White,& Tisher, 1986). In general, all cognitive activities are basically problem solving situations (Anderson, 1985). Therefore,in some sense the goal of science education is to generate problem solvers in. Problem solving in physics is of interest for at least two reasons: one, physics (chess, and algebra) problem solving gives insight into the cognitive process of experts and novices (Larkin, McDermott, et al) and two, physics is a common subject in high school and college, with problem solving being a specialized skill often required to pass physics. In fact physics problem solving is difficult generally, making physics a hard course to pass (Novack, 1982). Research into physics problem solving can lead to better teaching and learning in high school and college physics classes (Novack, 1982) (Larkin & Reif, 1979).

Protocols of a verbal nature were used at least as early as 1974 by Thorsland and Novack to analyze performance of college students in solving physics problems. A protocol of the verbal type is when a person thinks aloud so that his

thoughts can be recorded by the researcher as he performs a task. This technique was validated by Ericsson and Simon (1979) who determined that "there is no evidence that thinking aloud protocols (collected under neutral conditions) distort or interfere with the subject's thinking and that thinking aloud protocols very closely reflect the thought processes that occur during task performance" (Hayes, 1981). Larkin and Reif (1979) used verbal protocols of expert and novice physics problem solvers so that they could find what are the basic problem solving processes before and after instruction to get the novices to solve physics problems better. Also, they extended the protocol information of before and after instruction of physics problem solving to find out reliable instructional practices that would improve physics problem solving by novices. The use of protocols of expert and novice physics problem solvers culminated in the seminal in Science of Larkin, McDermott, D. Simon and H. Simon in 1980 (208, 1335-1342). In this article the authors applied the findings of cognitive psychology to physics problem solving of expert and novices so that they could also develop cognitve maps showing node-link structures in the expert's mind and computer simulations of the physics problem solving process. Later research of expert and novice problem solvers was done by Mandell (1980) who extended the idea to sixth-graders using interview techniques. It should be pointed out that

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Wright (1979) used the interviewing technique, after some science methodology problem solving by preservice students in teaching.

The results of using protocols, especially with expert and novice physics problem solvers, has lead to a number of research lines. After many years of work in developing a computer model for physics problem solving Novack (1980) Also, computer representations for information that was developed by the problem solver in the process of solving a problem and a compiler for translating computer programs written in such representations and a computer language for specifying such representations was developed. The understanding of physics problem solving processes and knowledge sturctures enables researchers to write computer programs which can automatically solve physics problems without the users being experts, can generate more effective physics teaching because the component processes of physics are made explicit in order to program the computer, and can be the basis of CAI (computer-assisted instruction) which answers questions about solutions of physics problems and can analyze physics problem solving failures of students.

Another line of research, in which interest has diminished is the relationship between successful physics problem solving an the Piagetian ideas of formal and

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concrete reasoning such as by Dukes and Strauch (1984). Present research in physics problem solving has been extended to help novice students in physics and chemistry (Ryan,), use of peer-interactions in physics problem solving (Amigues, 1988) teaching of physics problem solving (Roth, 1987), and more cognitive research as illustrated by the work of Anzai and Yokoyama (1984).

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